Magnetic Loop for 14 to 29MHz

K R (Dick) Harvey VK2BKH 7A/28 Woods Pde Fairlight 2094

THIS LOOP HAS BEEN IN operation for more than a year giving consistently good results. No claim is made that it is the ultimate possible, as much has been learned by its construction and use. The writer can recommend it in its present form as a worthwhile alternative for a dipole, being of particular value where space is limited, as is the case of the writer, living in a home unit.

The design is based on an article in the English magazine *Ham Radio Today* of December '89, written by G6VS. Much additional aid has been provided by letter and per CW from G4FM. Also, the *ARRL Antenna Handbook* of '88, chapter 5, has been very useful and is recommended reading for would-be "loopers".

Generally speaking, small antennas make use of loading coils to achieve resonance. If a large capacitor is used instead of coils together with a low-loss conductor formed into a loop, much greater efficiency is obtained (Ref *ARRL H/B).*

Having a radiator length of 102 inches of 3/4-inch copper pipe bent to make a circle of approximately 31 inches (depending on gap) and tuned with a capacitor of approximately 125 + 125pF, this loop covers from 14-29MHz.

On air, the writer finds the loop compares favourably with his multiple (five band) dipoles. The radiator length, slightly less than 1/4 wavelength on 29MHz, is the optimum for that band, so the loop's efficiency will be greatest at that frequency, dropping off at 14MHz where, of course, the length will be about 1/8 wavelength (Ref *ARRL H/B).* If maximum performance is desired on 14MHz, the loop diameter should be increased to approximately four feet. Coverage then would be from 14-7MHz.

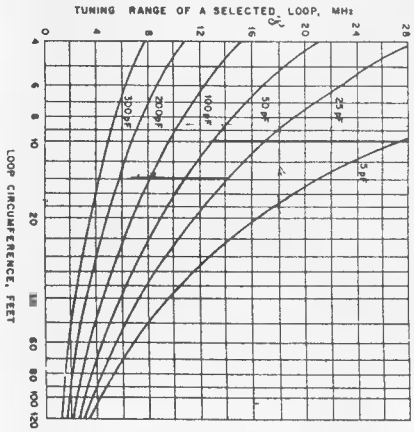
Construction should be clear enough from the diagrams and photos, but the writer has found it would have been better to have terminated the ends of the loop on the same side of the mounting base as the capacitor. This then would bring the gap under the weather cover, obviating the need for the external canopy at the back of the box as shown. More importantly, shorter connections to the capacitor would ensue.

The key to an efficient loop is to keep all resistance, both DC and RF, to a minimum. The lower the resistance, the higher the Q factor becomes, which in turn determines the bandwidth and the terminal voltages at the ends of the loop. So all connections should be as short and as perfect as possible (Ref G6VS).

Ideally, the copper tubing should be polished and given several coats of clear marine varnish to avoid losses (Ref I1ARZ).

The capacitor must be a split-stator to avoid the resistance introduced by the rotor connection of a standard one. Change of capacity is still obtained, the two halves being in series.

Special vacuum capacitors are made for this use. A much cheaper option is to replace the aluminium plates of a conventional capacitor with copper ones, soldering the ends of all plates together to avoid losses (Ref *ARRL).* The author has done this, but found no measurable improvement. The use of copper did seem, however, to maintain the efficiency against the gradual deterioration by weathering effects. Also connections to the capacitor can then be made by soldering. If only indoor use is envisaged, the aluminium plates would suffice.



Frequency tuning range of an octagon-shaped loop using 3/4-inch copper water pipe, for various values of tuning capacitance and loop circumference. (Courtesy ARRL Handbook *1988).*

Plate spacing is also very important, as very high RF voltages are generated at the gap in the loop. With 100 watts to the loop, voltages of 6000-7000 are encountered (Ref G6VS). Minimum spacing for 100 watts usage should be .080 inches (Ref *ARRL H/B).*

In the writer's case, the final capacitor was found by trial and error, changing spacing and number of plates until the desired tuning range was obtained. Some trimming of the radiator length was also necessary. The ARRL graph shown here (not available at the time) should be of assistance as a guide, noting it was compiled using an octagonal loop made of nominal 3/4-inch pipe (USA) which has an actual OD of 0.90 inches.

In regard to the use or not of the octagonal shape (Ref *ARRL* and G6VS). Round is the preferred shape as it encloses the maximum area for a given circumference, but the use of the octagonal would incur only a small loss and may be easier for some readers to construct. For example, G6VS made his by using a blow lamp to solder seven 45° Yorkshire fittings (ex-plumber's supplier) with eight short straight lengths of pipe interposed to make the octagon.

The author found the round shape not very difficult to make, as the stores mostly carry their pipe stock in big spiral coils. With this as a starting point, the pipe was filled with sand, well tamped down, and bent around a wooden former to size and shape.

Both gamma and half-Faraday loop coupling work equally well. The writer prefers the loop at it seems less affected by nearby metallic objects.

SWRs of 1:1 were readily obtained on 14/18/21MHz, rising to 1.4: on 24 and 28MHz.

In regard to the remote-control mechanism, there are commercial units using stepper motors with integral gear trains available from the USA and the UK, at a price.

For the home-brewer it will be largely a matter of personal ingenuity as to what items can be adapted to get the very slow speed of capacitor rotation needed. Pos-

sible sources are small computer motors with built-in gears, electric car aerials and even rotisserie motors.

In the writer's case, a small 6-12V DC motor (supplied from a variable power pack) drives a gear-chain removed from a discarded electric can-opener. This goes through a Meccano worm and gear-wheel combination (relics of boyhood days) to connect to the shaft of the capacitor.

A potentiometer is also coupled to the capacitor spindle (see diagram). The resistance of the potentiometer is such that when in series with a 1.5V cell and suitable meter (say 0 to 1mA), there is a full-scale reading at one end of the potentiometer's rotation, going down to zero at the other end. The potentiometer is then aligned with the capacitor so zero is read on the meter when the plates are in full mesh, going up to full-scale when the plates are fully out.

The meter can then be calibrated to show the various bands. The meter and battery are, of course, in the shack in a control box containing also a small PB On/Off switch to activate the motor, and a DPDT switch to provide forward and reverse motion.

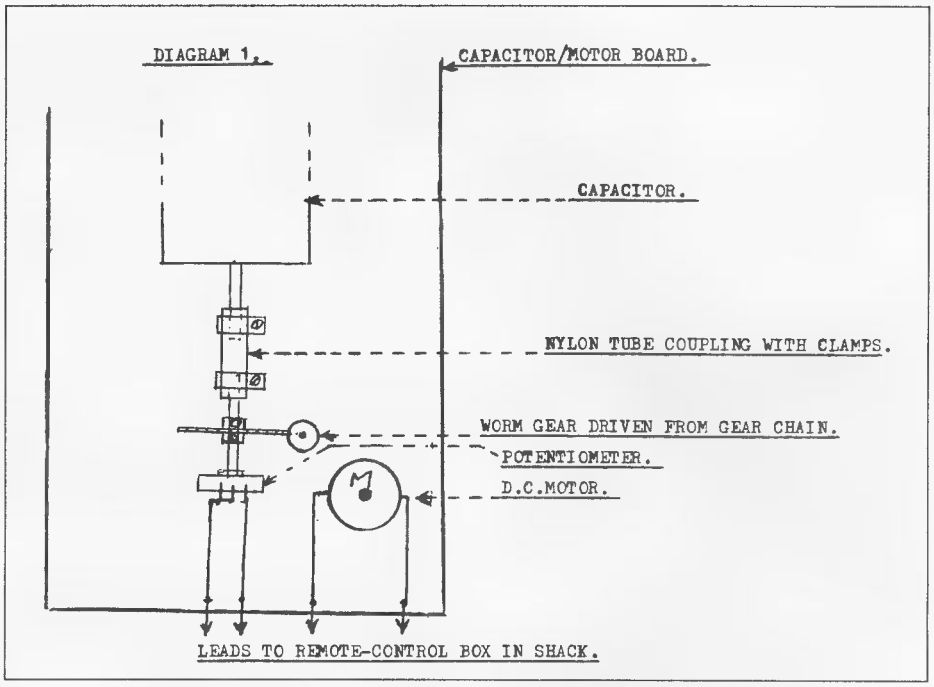
The variable voltage supply allows control over the speed of tuning. With this arrangement it takes about 20 seconds to rotate the capacitor plates from one end to the other using highest voltage. Having located the desired band the voltage is reduced to obtain the very slow speed necessary to tune exactly to minimum SWR.

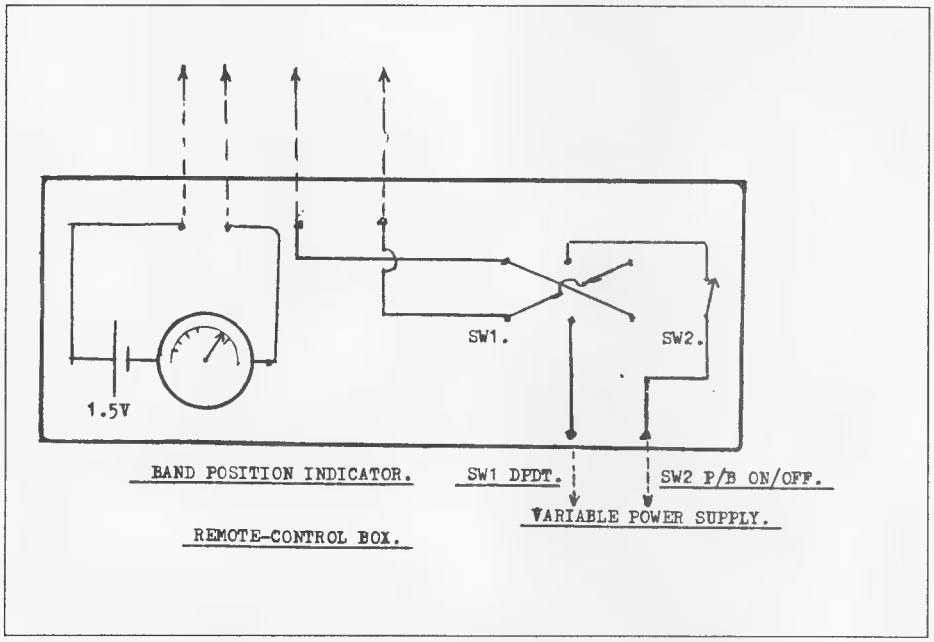
The exact centre of the loop's circumference is at zero (earth) potential so there is no need to insulate the loop from the mounting mast at this point.

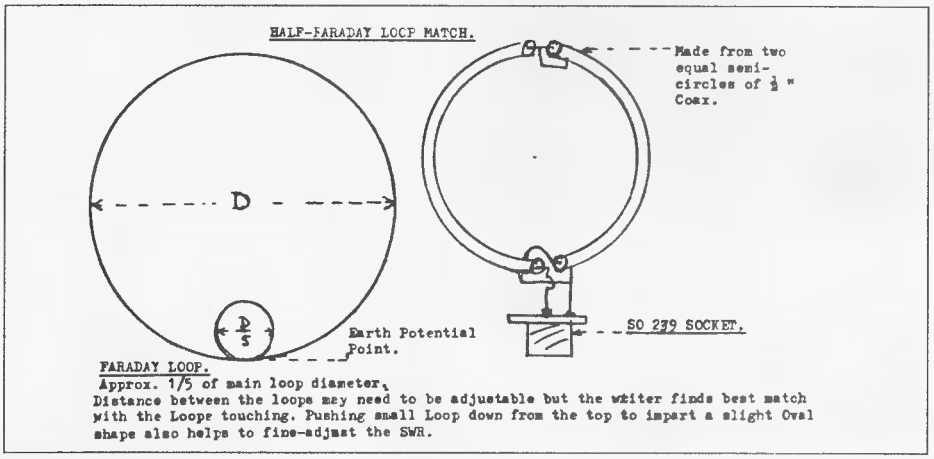
No earth is necessary, nor is great height. G4FM, who has been worked many times, has his loop up 7ft from ground, surrounded by thick stone-wall buildings, and it out-performs his Buternut vertical which is up 30ft.

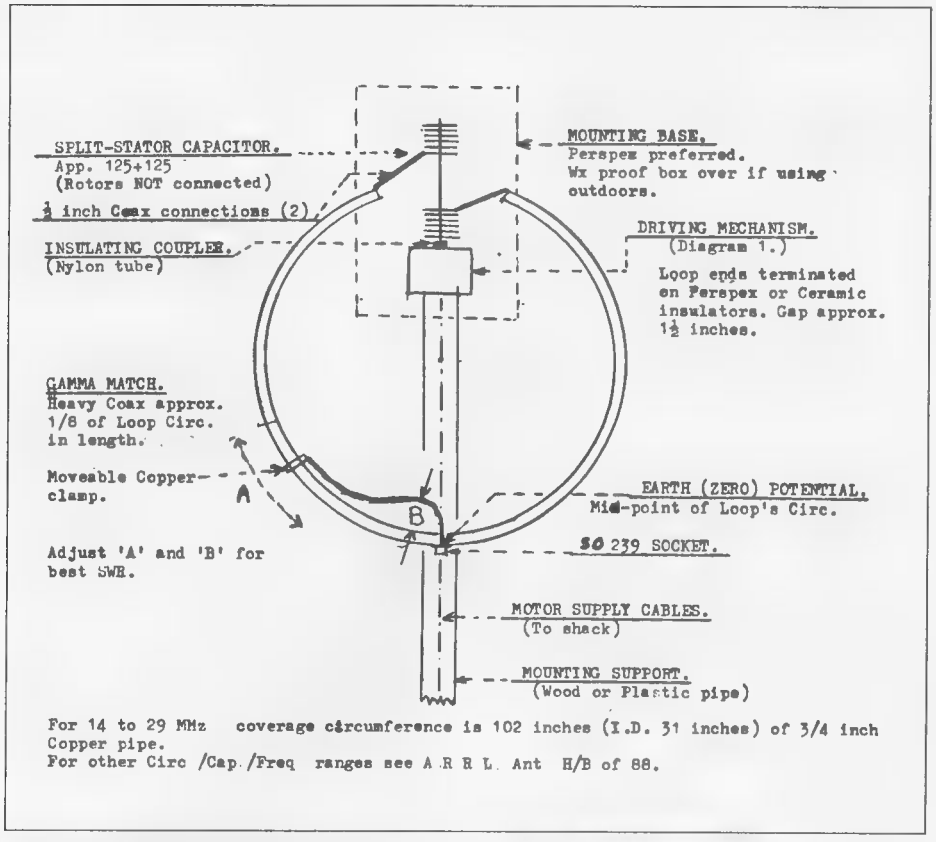
Loop radiation pattern is with the main two lobes lying in the plane of the loop (opposite of dipoles) so it is bi-directional. A rotator would be advantageous, but not essential, with the broad coverage obtained. Loops have low, medium and high angles of radiation so can replace both verticals and dipoles.

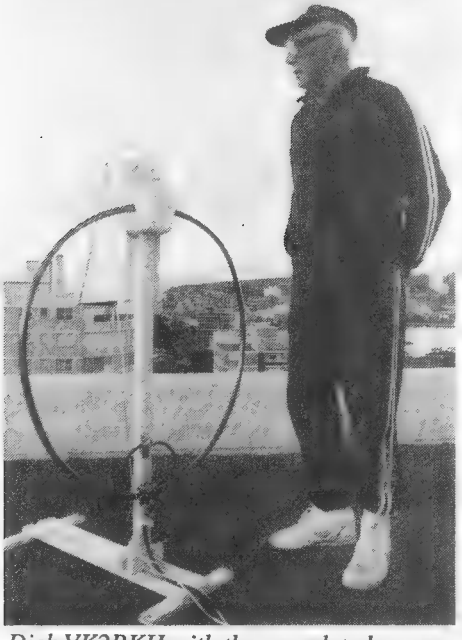
Magnetic loops can also be used in the horizontal position, in which case they become omni-directional with low angle of radiation. This appears to be the preferred position in the USA, where advertisements show commercial models such as the Isoloop and Comloop in the horizontal mode. Tests by the writer using the loop this way were disappointing. It appears great height is necessary (Ref *ARRL H/B*).



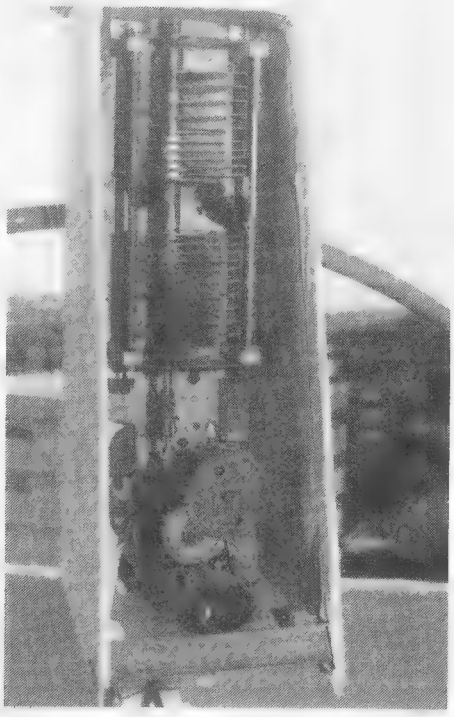



HALF-FARADAY LOOP MATCH.
Made from two equal semi-circles of ½" Coax.
D
D/5
Earth Potential Point.
SO 239 SOCKET.
FARADAY LOOP.
Approx. 1/5 of main loop diameter.
Distance between the loops may need to be adjustable but the writer finds best match with the Loops touching. Pushing small Loop down from the top to impart a slight Oval shape also helps to fine-adjust the SWR.


SPLIT-STATOR CAPACITOR.
App. 125+125
(Rotors NOT connected)
½ inch Coax connections (2)
INSULATING COUPLER.
(Nylon tube)
MOUNTING BASE.
Perspex preferred.
Wx proof box over if using outdoors.
DRIVING MECHANISM.
(Diagram 1.)
Loop ends terminated on Perspex or Ceramic insulators. Gap approx. 1½ inches.
GAMMA MATCH.
Heavy Coax approx. 1/8 of Loop Circ. in length.
Moveable Copper-clamp.
A
B
EARTH (ZERO) POTENTIAL.
Mid-point of Loop's Circ.
Adjust 'A' and 'B' for best SWR.
SO 239 SOCKET.
MOTOR SUPPLY CABLES.
(To shack)
MOUNTING SUPPORT.
(Wood or Plastic pipe)
For 14 to 29 MHz coverage circumference is 102 inches (I.D. 31 inches) of 3/4 inch Copper pipe.
For other Circ /Cap /Freq ranges see A.R.R.L. Ant H/B of 88.



Dick VK2BKH with the complete loop.



The split stator capacitor and slow motion drive assembly inside housing.

In the author's case, living in a high-rise block of home-units, the flat concrete roof used as an antenna farm is approximately 100 feet above ground level, an ideal take-off for any antenna. The loop's rather low mounting height (six inches) is dictated by the need to keep its size down to manageable proportions as it has to be carried up two flights of stairs, through narrow doorways to reach the roof, then over a 6ft-high safety fence to reach the outer area. Wind resistance is another consideration.

Actually this apparently favourable take-off is nullified to some extent by the fact that the loop is surrounded by big metal pipes, masonry walls enclosing clothes hoists, lead flashing around parapets, and is rather close to an array of multiple dipoles. In fact, the reference dipoles have a much clearer take-off, being another 17 feet higher at the peaks.

Initial tune-up would be to put the rig on receive at 21MHz, then to rotate the capacitor until a sharp increase in noise level indicates resonance. Then switch to transmit and, with a low-power carrier, again rotate the capacitor at very slow speed, backwards and forwards, until minimum SWR is obtained. The positions of the other bands are then easy to find in like manner. The face of the meter can then be calibrated to suit.

Unfortunately the author has no instrumentation with which to measure the high RF voltages at the gap in the loop which would be an indication of its performance. Instead the following criteria were used:

1. SWR
2. Field-strength readings under controlled and repeatable conditions.
3. Comparative F/S readings with dipoles.
4. Bandwidth as an indicator of Q. B/W is taken as twice the change in frequency to go from a SWR of 1:1 to a SWR of 1.5:1 (Ref G4FM).

B/W readings obtained in the writer's case were on 14MHz-24kHz; 18MHz-44kHz;21MHz-68kHz.

To summarise, in the writer's opinion, the magnetic loop is a very worthwhile small antenna. It requires no earth or radials, and takes up very little space. In comparison to other small antennas such as a whip it is more efficient, as no loading coils are involved.

In the USA, controversy has risen from claims made by the makers of commercial magnetic loops such as the Isopole and the Isoloop that their loops have a gain over a dipole. Evidently it is possible to prove this is theoretically impossible. Be that as it may, the writer tends to agree with G6VS and say that in his experience a well-built loop can perform equally as well as a dipole.

Finally, consideration should be given to a mono-band version where the radiator could be made the optimum length and smaller, cheaper capacitors used. For the very narrow WARC bands even fixed tuning with simple home-made capacitors is a possibility, thus doing away with the remote-control mechanism.

ar